



Canadian Council
of Ministers
of the Environment Le Conseil canadien
des ministres
de l'environnement

Review and Assessment of Canadian Groundwater Resources, Management, Current Research Mechanisms and Priorities

PN 1441

INTRODUCTION

The Canadian Council of Ministers of the Environment (CCME) is the major intergovernmental forum in Canada for discussions and joint action on environmental issues of national concern. The 14 member governments work as partners in developing nationally consistent environmental standards and practices. As part of a commitment to work collaboratively on key water issues, the Water Agenda Development Committee (WADC) contracted Golder Associates Ltd. to survey and report on the views of Canadian groundwater regulators, consultants, researchers and users with respect to knowledge and knowledge gaps of groundwater in the country; groundwater governance; linkages between surface water and groundwater management; and research. This document is a summary of the opinions of those surveyed and does not represent a conclusive survey on groundwater. As CCME work on groundwater is in early stages, the information in this report and other studies will inform further CCME work on groundwater policy needs and opportunities.

SURVEY METHODOLOGY AND LEVEL OF RESPONSE

The survey questions were designed to provide:

1. Identification of Groundwater Knowledge and Gaps – status of groundwater mapping and characterization; aquifer sustainability activities; understanding of groundwater/surface water interactions; parties using groundwater information; the needs of those agencies collecting and managing data.
2. Assessment of Groundwater Management in Canada – role and interactions of agencies, available regulatory tools and groundwater monitoring efforts.
3. Determination of the Status of Groundwater Research in Canada – number of researchers; research priorities at universities and private organizations; role of government agencies; number of students being trained in hydrogeology; and, current and future needs.

Information was obtained using a two-tiered survey mechanism. First, a web-based survey was employed to obtain feedback from a broad range of stakeholders. Three versions of the survey were used to solicit input from government agencies, academic institutions, and groundwater associations and private consultants. Of the total of 243 respondents invited to participate in the on-line survey, completed surveys were received from 104 individuals, resulting in an overall response rate of 40.6%.

Agency	Survey Sent	Response Received	Percentage
Federal, Provincial or Territorial Government Agencies	105	53	51%
Municipal Government, Conservation Authority, or Water Purveyor	52	20	39%

Academic Institution	36	14	39%
Groundwater Association or Private Consultant	63	30	45%

Following analysis of the feedback from the web-based survey, 33 in-depth interviews with selected stakeholders representing different geographical regions and organizations were conducted to further explore issues identified from the on-line survey results. Additional information was also gathered concerning enrollment in academic institutions, government management structures and regulatory mechanisms.

KEY FINDINGS

Groundwater Knowledge and Gaps

Survey respondents identified the following areas of knowledge as either lacking or most needing increased understanding. Many of the gaps identified in the knowledge were also identified in governance, management and research. Some issues, such as data access and groundwater / surface water interactions, were identified both as part of another gap area, such as groundwater sustainability, and individually.

Number of respondents	Knowledge gaps identified as significant by one or more survey respondents	
>20	<ul style="list-style-type: none"> groundwater sustainability 	<ul style="list-style-type: none"> groundwater quality
10-19	<ul style="list-style-type: none"> groundwater mapping and characterization 	<ul style="list-style-type: none"> groundwater monitoring data (water-levels and quality)
5-9	<ul style="list-style-type: none"> groundwater/surface water interaction groundwater extraction data 	<ul style="list-style-type: none"> water well record data stream flow data
1-4	<ul style="list-style-type: none"> access to groundwater data climate change groundwater protection 	<ul style="list-style-type: none"> geothermal salt water intrusion flow and transport in fractured rock

Groundwater Sustainability

Groundwater sustainability was identified by respondents as one of the foremost groundwater issues facing Canada today. In many areas of Canada, groundwater is or may soon come under stress from development pressures. The survey explored the opinions of respondents regarding the sustainability of the resource and how this is being dealt with. In some areas, there are

conflicting demands on groundwater to support municipal water supplies, commercial and industrial users, and ecosystems. Currently, some perceive that there are few mechanisms in place to reconcile these conflicting demands. Before such conflicts can be resolved, a better understanding of the factors contributing to groundwater sustainability is required.

Most of the sustainability analysis referenced by respondents is carried out as a requirement of permits to take groundwater. Withdrawal thresholds requiring analysis vary between provinces. In BC, Quebec and Newfoundland and Labrador, little or no sustainability analysis is reportedly being undertaken. In Manitoba, sustainable withdrawal rates have been established for a few aquifers based on estimates of long-term average recharge rates. In Ontario and the Atlantic provinces, the analysis is usually considered in the context of an individual groundwater allocation application. Consideration of the cumulative effects of groundwater withdrawals on an aquifer-wide basis is rare.

Concern was expressed with the amount and quality of sustainability analysis currently being conducted, data accessibility, methods used and lack of conflict resolution mechanisms. Specific concerns include little consideration of cumulative impact from withdrawals, need for a better understanding of effects of takings on stream flow and aquatic life, and considerable uncertainties related to groundwater/surface water interactions, baseflow requirements, aquifer characterization, the effects of climate change and current groundwater withdrawals.

Opportunities for improvement that were raised most frequently were the need for additional data in the form of groundwater levels and to a lesser extent, groundwater quality monitoring data, together with improved estimates of groundwater usage and coupled groundwater/surface water information.

Responses indicate a need for assessment of aquifer sustainability, on an aquifer or watershed basis, and considering the cumulative effects of groundwater withdrawals on the environment. Mechanisms for the incorporation of baseflow requirements and resolving conflicts between competing water users are considered key to this.

Groundwater Quality

While many areas of Canada are characterized by high quality groundwater, the resource is threatened in some areas by contamination from natural sources and anthropogenic sources related to residential, commercial, industrial and agricultural land use. Groundwater quality tied with groundwater sustainability as the most significant groundwater issue in Canada raised by respondents.

Among the issues related to groundwater quality, nitrates and pathogens were raised most frequently by respondents. Monitoring of these is considered insufficient. There are few records

correlating the rate of illness associated with groundwater-borne contamination. The understanding of the behaviour of nitrates in groundwater is considered to be good, but information concerning the source as it relates to agriculture is felt to be inadequate. The management of nutrient applications related to agricultural land use raises particular challenges with respect to the balance of societal needs for both food and water. A need for better strategies to deal with nitrates in agricultural areas was identified.

The use of road salt and its potential impact on groundwater was raised, highlighting the challenge of balancing public safety with the protection of groundwater quality for domestic and municipal water supply.

In areas where groundwater is commonly derived from bedrock aquifers, such as British Columbia, Ontario, Nova Scotia and Newfoundland and Labrador, groundwater quality issues related to naturally occurring contaminants such as arsenic, uranium, fluoride and radon were raised. In these areas, there is a lack of groundwater quality data required for geochemical characterization. Other potential groundwater quality impacts raised included those related to aggregate extraction and the need for decommissioning of abandoned wells.

Pharmaceuticals in groundwater (*e.g.*, endocrine disrupting chemicals) was raised as an emerging issue. There are uncertainties concerning the behavior of these constituents, together with their potential impact on human health and ecosystems.

Groundwater Mapping and Characterization

The status of groundwater mapping and characterization in Canada varies by region. Some provinces are considered to be well mapped, while in other provinces, additional mapping efforts are required. The perception of the adequacy of this mapping varied dependant on who was being interviewed. Most municipal respondents felt that most aquifers have been characterized, provincial representatives felt that a “moderate” number of aquifers had been mapped, and federal representatives felt that a “limited” number had been mapped. This may reflect the “scale” on which the respondent is working, local to country wide, and the perception of need.

The need for comprehensive mapping and characterization of aquifer boundaries was raised by many in the detailed interviews. In British Columbia, over 900 aquifers have been classified in accordance with a provincial aquifer classification scheme. Relatively significant resources have been set aside for aquifer mapping in Ontario and Alberta. Quebec initiated a five-year hydrogeological data collection and mapping program in 2008. NRCan has initiated a number of programs for groundwater mapping of 30 “key” aquifers, such as the Annapolis Valley and Moncton Basin, across the country through agreements with a number of provinces. Concerns raised regarding these existing programs include: frustration that existing mapping is not readily available in Ontario; funding for the Quebec initiative is low in comparison to the amount of

mapping needed; and large areas in Nova Scotia, particularly those characterized by bedrock aquifers, where fundamental information concerning hydrostratigraphy, aquifer parameters and geochemistry is absent. Mapping methodologies are considered variable, depending on the information available and the resources allocated to the task.

Responses indicate a need for additional mapping and characterization of groundwater resources throughout Canada in a consistent, coordinated manner

Groundwater Data

Groundwater data available from most provincial government agencies consists of water well records, pumping test data, hydrogeological maps and studies, water quality data, groundwater level monitoring data, information on groundwater extraction, geophysical logs, groundwater vulnerability mapping and capture zone analysis. The most common users of this information are consultants, academic institutions, government agencies and the general public.

Many respondents indicated that while “research” is traditionally considered the key to filling gaps in groundwater knowledge, what is most needed by practitioners is access to groundwater data. In some cases, sufficient data is not being collected. Relative dissatisfaction with the amount of groundwater quality information being collected was expressed by some. Others felt the data is being collected but is not adequately managed or is not readily accessible to practitioners.

The greatest groundwater data need identified is improved access to the data, particularly raw data that are accessible electronically and on-line, up-to-date, of reliable quality, and sufficiently local in nature. In many current government data management schemes, information is located in many places; the storage sites for data are often not readily apparent, and much searching may be required. In addition to federal and provincial databases, information is also contained at the local level at municipalities and conservation authorities, together with files maintained by private consulting, mining and environmental firms. Tracking down all available data when conducting a study may be a daunting task; consolidation of data within one agency would be valuable.

Responses identified a need for significant efforts to provide provincial databases of groundwater information that are readily accessible on line, of reliable quality, and up-to-date, with dedicated staff with sufficient database and computer skills to manage these

Surface Water/Groundwater Interactions

Uncertainties related to groundwater/surface water interactions were raised as one of the most common understanding gaps, particularly in the context of aquifer sustainability analysis. A lack

of stream flow data, knowledge concerning in-stream spatial and temporal flow needs, particularly for maintenance of viable aquatic habitat, and lack of information concerning the processes related to groundwater/surface water interactions themselves, including the characteristics of the hyporheic zone were identified.

The use of an in-stream flow needs evaluation in groundwater assessments and the use of groundwater information as part of decisions pertaining to the support of ecosystems and stream flow are limited. Respondents were unsure of what was expected by regulators to demonstrate that there is no significant impact to baseflow as all groundwater withdrawals will result in an impact of some kind.

The processes that govern infiltration and evapotranspiration, that are critical to the assessment of recharge, are not understood in the context of groundwater budgets and groundwater quality (especially on a seasonal, diurnal and extreme event scale). Similarly, the role of the vegetated surface and the vadose zone are poorly understood, from both a water balance perspective, and with respect to the transfer of nutrients. In the Atlantic provinces, the role that groundwater serves in estuaries is uncertain, together with its effect on benthic organisms at the groundwater/estuary interface.

Responses identify that the assessment of groundwater/surface water interactions could best be improved through integrated groundwater and surface water monitoring data, together with additional hydrogeological mapping and stream flow data. Respondents referenced the need for case studies and guidance or prescribed methodologies to assist in these assessments. Assessment tools identified include coupled groundwater/surface water models and the use of hydrochemistry. The need for research related to improved field methodologies and improved understanding of water quality interactions and ecological needs was raised.

Other Identified Knowledge Gaps

The potential effects of *climate change* are reportedly considered in a “limited” number of groundwater sustainability studies. Most studies that have included an assessment of climate change are those related to environmental assessments and large basins studies, such as the Okanagan study currently underway by NRCan. Some felt that resources would be better allocated to developing improved understanding of the resource and the interaction between groundwater and the atmosphere, than trying to predict climate change effects with inadequate science.

Concerns related to groundwater sustainability and threats to groundwater quality led some respondents to identify the need for groundwater protection as an issue. Groundwater protection, where implemented, uses land use controls and other measures to provide protection of groundwater quality and quantity and may use water use controls to provide protection of groundwater.

Geothermal or earth energy was raised as an emerging groundwater issue. With the increasing interest in “green energy”, geothermal applications are seeing increasing usage in urban areas such as Toronto, Winnipeg, the B.C. Interior and the Atlantic provinces while traditionally they were more common in suburban areas (except Winnipeg). Concerns identified include insufficient guidance or regulation related to the development of geothermal energy, quality issues such as the generation of thermal gradients and the potential impacts on groundwater quality and receiving surface water, and quantity and flow interference from open loop systems.

The potential for seawater intrusion, was identified, particularly in PEI and B.C. while Manitoba indicated that migration of fresh water/saline water boundaries due to groundwater development is a concern in some aquifers.

Issues raised regarding the flow and transport in fractured rock include the requirement for further characterization and construction of coupled structural and hydrogeological models; uncertainties concerning the delineation of wellhead protection zones in fractured rock, and the need for more work concerning the effectiveness of hydrofracturing to increase well yield.

Groundwater Management in Canada

Responses indicate that the challenges related to groundwater management are equally weighted between a lack of regulation and available management mechanisms, together with insufficient groundwater information. A lack of information on groundwater usage was one of the most commonly cited information gaps. Concerns related to lack of funding, resources, expertise and coordination amongst regulatory authorities was also raised. Many suggested that challenges to groundwater management are related to the lack of recognition of the value of the resource.

Suggested improvements focus on enhancements to existing legislation, together with access and availability of groundwater information. The need for additional funding was cited, together with the importance of public education on groundwater management issues.

Federal Government

Environment Canada is the lead federal department on water (including groundwater), with the mandate to preserve and enhance the quality of the natural environment, including water. NRCan is responsible for implementation of the federal government’s commitments to understanding the physical components of groundwater systems, namely, groundwater quantity and characterization, together with the assessment of ambient groundwater quality. Other federal agencies that are involved in groundwater-related issues include Health Canada, the Department of Indian and Northern Affairs with respect to groundwater issues beneath First Nations land; Public Works on site development and contamination issues; Transport Canada on infrastructure development and the Department of Fisheries and Oceans. Agriculture and Agri-Food Canada (AAFC and the Prairie Farm Rehabilitation Administration, PFRA) has recently established a

national presence with primary responsibilities on issues related to irrigation and farm water supply but has assumed a role in groundwater mapping, groundwater quality, well maintenance and abandonment, and funding infrastructure development as well.

The division of responsibilities between Environment Canada and NRCan with respect to groundwater was not clear to all respondents. Some respondents felt that issues of groundwater sustainability and ecosystem protection, and emerging issues such as climate change, geothermal applications and emerging contaminants would be well suited to the development of guidance at a federal level.

Provincial Governments

The regulation of groundwater supply and protection falls primarily under provincial jurisdiction. The provincial governments are responsible to provide the overall strategy, applicable laws and regulations, technical studies, support, funding, and public education required to manage groundwater.

Within the provinces, groundwater is largely managed by the provincial Ministries of Environment or equivalents. These agencies interface with various federal agencies including those listed above, provincial health agencies on drinking water quality and septic systems; provincial agriculture agencies on water supply for irrigation and water quality issues; provincial municipal affairs agencies on subdivision approvals; provincial agencies related to mines and natural resources on mapping, exploration and development, and provincial transportation and public works agencies on infrastructure. The provincial groundwater agencies also interface with local governments (including municipalities, conservation districts and watershed and aquifer management boards) on issues related to groundwater supply and protection, together with academic institutions, groundwater associations, consultants, First Nations, private citizens and industry.

In the Yukon, groundwater management is undertaken by Environment Yukon's Water Resources Branch. Similar responsibilities for groundwater management have not been established in the Northwest Territories and Nunavut.

Given Canada's vast size and the significant variations in local hydrogeology, most respondents agreed that groundwater is best managed at the provincial level by the Ministry of Environment or equivalent Ministries or Departments. Collaboration with the Ministries of Health was generally viewed to be good; however, in some cases better communication and coordination is needed.

Most viewed the role of the provincial governments as providing the overall strategy, applicable laws and regulations, technical studies, support, funding, and public education required to

manage groundwater. In some provinces, the perception of some respondents was that not all of these needs are being met.

Local Governments

The role of municipalities in groundwater management varies considerably. Large purveyors such as the Regional Municipality of Waterloo and the York, Peel, Durham and Toronto-Conservation Authorities Moraine Coalition (YPDT-CAMC), are able to retain groundwater professionals and advancing groundwater management. A lack of access to resources and technical experts in many municipalities make management decisions at a local level difficult.

Many respondents suggested that sound policy, direction and leadership on groundwater management should be established at the provincial level, but that control and monitoring of the resource should be carried out at the local level by management groups comprised of municipalities and conservation authorities. The rationale for this approach is that these agencies already bear the associated responsibilities for local land use planning, environmental protection, municipal supply and flood protection. Other respondents felt that delegation of groundwater management to local governments represents a downloading of provincial responsibilities and that local governments may be given the responsibility without the adequate authority or funding. Some respondents felt that, groundwater management would benefit from municipal representation on federal and provincial committees where decisions are being made.

Groundwater Legislation

Challenges related to the interpretation, implementation, enforcement and compliance of the regulations were identified. Federal and municipal respondents expressed concern regarding the ability of available legislation to effectively address groundwater management. In some provinces, the need for basic regulations related to groundwater withdrawals were identified. Elsewhere, respondents indicated that additional requirements for well construction, well tagging, and mandatory submission of well records, water quality testing and reporting, and inclusion of private and dug wells in licensing programs would be beneficial.

While the need for improvements to existing groundwater legislation were identified by respondents, one of the themes emerging from the survey was that, in many cases, additional monitoring and enforcement, rather than regulation, is required to ensure the protection of the resource. Suggested improvements included additional government commitment and coordination, development of an overall philosophy to guide regulation, additional funding, science-based decision making and suggestions ranging from enhanced powers to the provinces to management on a municipal, watershed and aquifer basis. Also identified was the need for leadership, technical support and public education related to groundwater assessment and management at the provincial level.

The Value of Groundwater

The lack of recognition of the value of groundwater as a resource was a repeatedly raised theme. Groundwater is considered to be out-of-sight, poorly understood and expensive to investigate. Unlike other natural resources, its resource potential is largely unknown and there is relatively little pricing associated with groundwater. As a result, there has been little incentive to manage the resource effectively.

Responses suggested that consideration should be given to expending more efforts towards “knowledge translation” and transfer to facilitate communication of the implications and policy requirements related to the science, and making groundwater issues more understandable to policy makers and the general public.

Funding

One of the biggest obstacles identified by respondents to groundwater management and governments’ ability to carry out their mandates is a lack of adequate funding and resources. In some provinces, the need for one or more additional staff members and additional expertise was identified, while in others, it was estimated that current resources need to be significantly increased to allow ministries to better carry out their current and planned future mandate.

Other resource considerations include the manner in which groundwater studies are currently funded. The current trend is to provide funding on a “project-basis”. These types of funding mechanisms may not always allow for a sustained commitment to groundwater assessment and management. Rather, proper assessment and management of groundwater requires a long-term strategy, on the order of 10 to 20 years in duration, with associated milestones and monitoring.

Inter-Agency and Inter-Disciplinary Coordination

The need for improved communications between the federal government and the provinces was raised. Some respondents have suggested that coordination between federal and provincial representatives is happening at the technical level but not always at the management level. Responses suggest that consideration should be given to establishing a long-standing group of federal and provincial representatives from both the science and policy side to facilitate ongoing cooperation on research into and management of groundwater in Canada, together with the development of some of the guidance described above. Inclusion of local government representation was also proposed by some.

The lack of integration between surface water and groundwater management in most jurisdictions is a significant concern. To a large degree, the two water resources are managed by separate agencies within both the provincial and federal governments (with some exceptions, PEI for one). It was suggested that water management would benefit from improved collaboration

between managers of groundwater and surface water and that consideration should be given to better cross-training of professionals in these two disciplines to improve collaboration.

Groundwater Research in Canada

Research needs identified by respondents included groundwater/surface water interactions; the definition of recharge rates and mechanisms for key aquifers and basins; and groundwater sustainability. Because investigation of these conditions cannot be carried out without first characterizing the basic groundwater flow regime, the need for basic hydrogeological data, together with aquifer mapping and characterization, was also highlighted by respondents. The largest number of faculty and students in hydrogeology reside at the University of Waterloo. Significant numbers are also associated with the University of British Columbia, the University of Calgary and Ecole Polytechnique de Montreal.

In general, responders felt that Canadian academic institutions are preparing students with the necessary skills to work as hydrogeologists in business, government and research. However, some felt that there is too much emphasis on contaminant hydrogeology at some universities and insufficient training related to groundwater resource evaluation. One reason identified for this is that, in Canada, much of the funding for hydrogeological research originates from mining, oil sands and other industry. Much of the available government funding is perceived to be associated with subject areas that receive the greatest public attention, with current interests related to topics such as climate change and human health rather than on issues considered important from the practitioners or researchers perspective.

SUMMARY

The scoping report prepared by Golder Associates Ltd. surveyed a representative cross-section of the groundwater community in Canada to obtain their views on the current state of groundwater knowledge in the country and needs for knowledge enhancement, groundwater governance, the linkage between surface water and groundwater and, very briefly, the level of research being carried out in the university setting. The findings of this survey are intended to provide insight into the major issues facing groundwater management and governance in Canada and lead to improvements in how this resource is considered in the future.